CHAPTER 1

INTRODUCTION

1-1. Purpose.

a. This manual provides guidance for engineers in the planning and design of heating, ventilation, and air-conditioning (HVAC) for hardened military and strategic facilities at new or existing Army installations. The material presented includes data for auxiliary equipment systems with special reference to underground installations not normally covered in HVAC manuals.

b. The term "hardened' applies to facilities intentionally designed to be resistant to conventional explosive effects, nuclear weapons effects, chemical or biological attack, and intruder attack. This manual addresses the technology of HVAC systems as it pertains to hardened facilities without regard to a specific type of attack, unless specifically required for design purposes.

c. Because of continuing research in the offensive and defensive techniques of warfare, it is strongly recommended that close coordination be maintained with the Commander, U.S. Army Corps of Engineers, Attention: HQDA (DAEN-ECE-T) Washington, D.C. 20314-1000 and the U.S. Army Armament Munitions and Chemical Command (AMCCOM) Chemical Research and Development Center (CRDC), Attention: SMCCR-PPP, Aberdeen Proving Ground, Maryland 21010-5423.

1-2. Scope.

a. It is outside of the scope of this manual to cover explicitly all rules and procedures pertaining to HVAC design; however, the manual is written for HVAC engineers possessing state-of-the-art expertise in their discipline but who are unfamiliar with the requirements of hardened installations. Wherever possible reference is made to design data guidelines and information included in other references. Only design data that is not easily found elsewhere is included in the present manual.

b. Decontamination facilities and other HVAC protection against chemical and biological agents and radiological fallout are included in this manual, but the design of hardened facilities is covered in the references listed in appendix A. In particular, the TM 5-858 series of manuals pertains to "Designing of Facilities to Resist Nuclear Weapon Effects". In addition, TM 5-855-1 provides guidance for the design of facilities subject to non-nuclear attack, and TM 5-855-5 provides detailed guidance for protection from nuclear electromagnetic pulse.

1-3. Criteria.

a. After establishing the requirements for a hardened facility, concept criteria are developed based on environmental constraints, mission requirements, system configuration, and facility operational modes.

(1) In particular, the engagement or operational scenario defines the degree and time of isolation required, the length of warning time the facility commander will have prior to attack, the design weapon effects, and other operational conditions which are necessary for design and operational reliability of the facility.

(2) Complementing the scenario, associated design criteria are developed on local soil conditions; size and proximity of weapon detonation; type and quantity of fallout debris, dust, or ejecta;, and growth factors to be plugged in the sizing of equipment; as well as other design factors.

(3) From the scenario and associated criteria, the HVAC designers will extract conditions, time periods, and events which will dictate the configuration and design of the facility environmental and associated auxiliary systems. For example, the warning time, weapon effects, RFI protection, and degree of isolation will dictate the response time of the closure devices required to seal the outside air intakes and to isolate the facility from airborne chemical biological (CB) contaminants.

b. The HVAC criteria for temperature, humidity, and other air quality conditions required in hardened installations are similar to those maintained in conventional surface structures when the missions are similar. The conditions peculiar to underground use are emphasized in this manual, with some data and information applicable to general HVAC problems included for the sake of convenience.

c. The heating and air-conditioning system must maintain conditions suitable for personnel efficiency and for material preservation and operation of essential equipment during standby, normal-operating, and attack and post-attack periods. Rejuvenation of the air will also be considered for conditions of extreme emergency and disaster. Steady-state environmental requirements during peace time and war time will exist only in such facilities as unmanned and sealed-up material storage facilities. All other hardened facilities within the scope of this manual must be designed to function throughout a wide range of operating conditions influenced by season, manning levels, and mission. Facilities are classified by operational requirements in accordance with the following:

(1) *Continuous operation.* The HVAC designer will be required to develop environmental systems that will function throughout all operating conditions. Ventilation air must be filtered for space pressurization. Essential parts of the HVAC system must survive the threat, although some non-essential components may be sacrificed as long as the system as a whole continues to function. Command and communication centers, surveillance and intercept radar, and missile launch and control centers are indicative of this type of facility.

(2) Button-up with active survival., Facilities of this type are designed to cease operations when attacked, to button-up and become isolated during the attack, and to resume operations after necessary repairs are made. The primary function of this type of installation is to protect personnel and equipment. Underground industrial plants, administrative agencies, and air raid shelters normally conform to this facility category.

(3) *Button-up with passive survival.* Facilities of this type will be designed as a protective structure with seal-up provisions only to prevent contamination of the protected material. Seal-up provisions will consist of closing doors and dampers upon notification of a threat and keeping them sealed until the threat is over. Underground facilities for storage of materials with high strategic or replacement value, such as archives and art objects, would be representative of this type of facility.

1-4. Operating modes.

a. Overview. The facilities under consideration must operate in peace, war, and under the threat of war. It is beyond the scope of this manual to set forth specific operational procedures required for each condition; however, operational and design assumptions must be made prior to design. The installation of equipment and operation of the structure is based on the following operating modes.

b. Normal conditions. A normal condition exists when” a structure is continually occupied and prepared for the accomplishments of a mission. Normal conditions will exist prior to button-up.

(1) Facility power will normally be provided by a commercial utility, though many facilities switch to emergency power when storms occur because of unreliable commercial power.

(2) HVAC systems will be operating with the design outside air passing through CB filters. Bypassing the CB filters will not be allowed unless facility mission is minor, and continuous protection against covert attack is not required by the operational scenario. Air from areas such as toilets, equipment rooms, and power plants will be exhausted to the outside.

(3) Waste heat will be rejected to the outside through normal cooling towers or radiators. Heat sinks will normally be filled and maintained at design temperature because the time required to lower the heat sink to its design temperature is greater than most warning periods.

c. Alert conditions. An alert condition exists during a real or practice exercise. In the alert mode, steps will be taken to improve the defense posture of the facility.

(1) The facility power plant will be put in operation and will either share the load with the public utilities or carry it all as prescribed in the operational scenario.

(2) No CB filter bypasses are permitted under any conditions. This must be the case because detectors will only indicate that gases or chemicals have been introduced into the system or broken through the filters, leaving no time to take preventive action. Combustion air will continue to be drawn through primary dust scrubbers. Personnel movement in the unoccupied facility areas unprotected by the CB filters will be curtailed.

(3) The button-up period normally commences with the alert alarm and continues until the seal-up period starts. Limited egress and ingress may be permitted. In shallow buried facilities, the prime movers are supplied from unhardened fuel storage, and the unhardened cooling towers remain in operation. All other systems are sealed from the outside except for air supply.

(4) Hardened heat rejection equipment will be utilized if attack is imminent and throughout the seal-up period covered in *d(2)* below.

d. Attack conditions. Attack conditions exists when weapons have been detonated in the area. The atmosphere may be contaminated and weapon effects may have rendered external cooling water equipment inoperative.

(1) In the attack mode, the facility is closed to protect filters, personnel, and pertinent equipment from blast pressure. The HVAC system is totally isolated from the outside. Ventilation and exhaust air is recirculated through carbon filters for odor removal. The prime mover combustion air is ducted through the primary dust separator and a scrubber for dust removal and temperature control. Contaminated dust slurry from the scrubber is piped to the outside. Facility operation is independent of commercial power.

(2) The seal-up period begins with attack warning and continues until the outside environment is tolerable. Fuel is supplies from hardened tanks, and cooling water is supplied from hardened heat sinks and cooling towers.

e. *Disaster conditions.* Under disaster conditions, the installation is inoperative due to damage or exhaustion of cooling water, fuel, or oxygen. To sustain life it may be necessary to utilize oxygen generation and carbon dioxide absorption equipment.

f. Postattack conditions After an all clear signal from an attack has been given, the facility can return to an alert condition The post-attack conditions end when the facility objectives are completed.

g. *Other conditions.* The period from button-up or weapon detonation to attack completion is also known as transattack and may range from minutes to days. Together with the postattack it is collectively referred to as the facility endurance period or simply facility endurance.

1-5. Hardened configuration.

a. The primary objective of a hardened structure is to withstand the effects of hostile weapons and complete the missions for which it was designed. Depending on the degree of hardening and the nature of this mission, hardened structures may be above or underground.

b. A structure is aboveground when all or a portion of the structure projects above the ground. Structures mounded over with slopes steeper than 1:4 are considered aboveground.

c. With respect to the ground surface, a structure is flush or partially buried when its rooftop is flush or buried less than half the structure diameter. Below these levels the structure is deep or shallow-buried depending on whether or not the buried depth enables it to absorb a direct overhead burst. Fortifications and air raid shelters are usually the shallow-buried type and equipped with blast doors, baffles, and labyrinth entrances to provide some blast attenuation.

d. A deep buried facility so defined is a structure buried deep enough that the direct induced ground motion effects govern design rather than air induced effects. Deep-buried installations can be made almost invulnerable and are generally used for protection of large one-of-a-kind facilities such as command and control centers, which cannot risk relying on redundancy or dispersion to ensure operability. Such important installations are invariable located in hard rock to use the strength of rock for protection and because rock is usually found at the depths of burial necessitated by nuclear weapons of the megaton class.

(1) Deep underground structures are the most costly and present the most operational problems. Deep-underground facilities typically can be several hundred or thousand feet below the surface. Deep-underground facilities must have survivable entrances, exits, communication links, etc., which will be shallow-buried *or* aboveground facilities. The designer must ensure that the appropriate weapon effects are considered for each component of the facility.

(2) Some features of the structural arrangement of a depe-underground installation affect the size and design of the air-conditioning system. Relevant definitions are as follows:

(a) Bare chamber. An underground chamber with no covering on the rock walls or ceiling that appreciable affects heat transfer. Walls painted to improve illumination of the chamber are considered bare from the heat-transfer standpoint A chamber with a concrete floor poured on the underlying rock is also considered a bare chamber.

(b) Lined chamber. An underground chamber with a wall covering of concrete or other material in contact with the rock walls and ceiling. Liners may consist of insulating or acoustical material and may contain a vapor barrier.

(c) Internal structure. A building or enclosure erected within an underground chamber to house equipment or facilities. The internal structure reduces the heat transfer from the occupied space to the rock and influences the dehumidification load.

(d) Annular space. The space around an internal structure, between the structure and the rock walls, floor, and ceiling of an underground chamber

e. Structurally, there is the greatest difference between the different types of hardened facilities just described, but from the HVAC viewpoint there is much less difference because of the necessity of providing openings to let air, personnel, equipment, and supplies in and out of the facility. This manual will focus attention on the main complicating factors underground, which are the heat and moisture transfer at the boundaries of the occupied space. Mathematical conventions used throughout this manual are listed in appendix B.

f. Occupant survival and ability to function is necessary for accomplishing the mission of practically all hardened facilities. Preventing entry of CB contaminants into the facility when attacked is vital in this respect. The HVAC design must be conservative to a degree consistent with the other elements of the facility. Long term mission, for instance, will require the facility to withstand multiple attacks and to continue to function with minor repairs and resupply. Coordination of these design objectives should be spelled out in the criteria. Design information to fulfill these objectives are discussed in the five remaining chapters with definitions of abbreviations and terms contained in the glossary.